MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

August 23, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator
3. MODIS - Scheduler Discussion
4. HDF Status

ACTION ITEMS:

05/03/91 [Lloyd Carpenter and Tom Goff]: Prepare a Level-1 processing assumptions, questions and issues list, to be distributed to the Science Team Members and the MCST for comment. (The list, the executive summary, information on the EOS Platform Ancillary Data, and a cover letter were delivered for signature and distribution.) STATUS: Open. Due date 06/07/91.

06/07/91 [Liam Gumley]: Speak to Alan Strahler, when he returns, regarding his MAS requirements. (Strahler will be contacted when he becomes available.) STATUS: Open. Due date 07/05/91

05/31/91 [Al McKay and Phil Ardanuy]: Examine the effects of MODIS data product granule size on Level-1 processing, reprocessing, archival, distribution, etc. (Reports were provided on June 21 and 28, 1991.) STATUS: Open. Due Date 06/21/91

06/28/91 [Lloyd Carpenter and Tom Goff]: Prepare a detailed list of scheduler assumptions in relation to Level-1 MODIS processing scenarios. (Lists were provided on July 26 and August 16, 1991.) STATUS: Open. Due date 07/26/91.

Progress on MAS Level-1B processing system development

Progress up to 23 August 1991

Recent effort has been concentrated on the continued development of MAS thermal infrared band calibration software.

Since spectral response functions are not yet defined for the MAS IR bands, it has been necessary to develop calibration routines which will accept the spectral response functions when they become available. This software has been tested with the current MAMS spectral response functions.

Testing of the MAS Planck radiance computation software revealed differences from the values computed by the MAMS software (function PLANK). Chris Moeller at Wisconsin was contacted regarding this problem. He responded with updated spectral response files, central wavenumbers for the MAMS bands, and monochromaticity correction factors.

Testing of the MAS software with the new spectral responses against the MAMS software with the updated coefficients showed that the differences were now small. Chris Moeller was advised of the scale of the differences and he agreed that the numbers were now acceptable (see over).

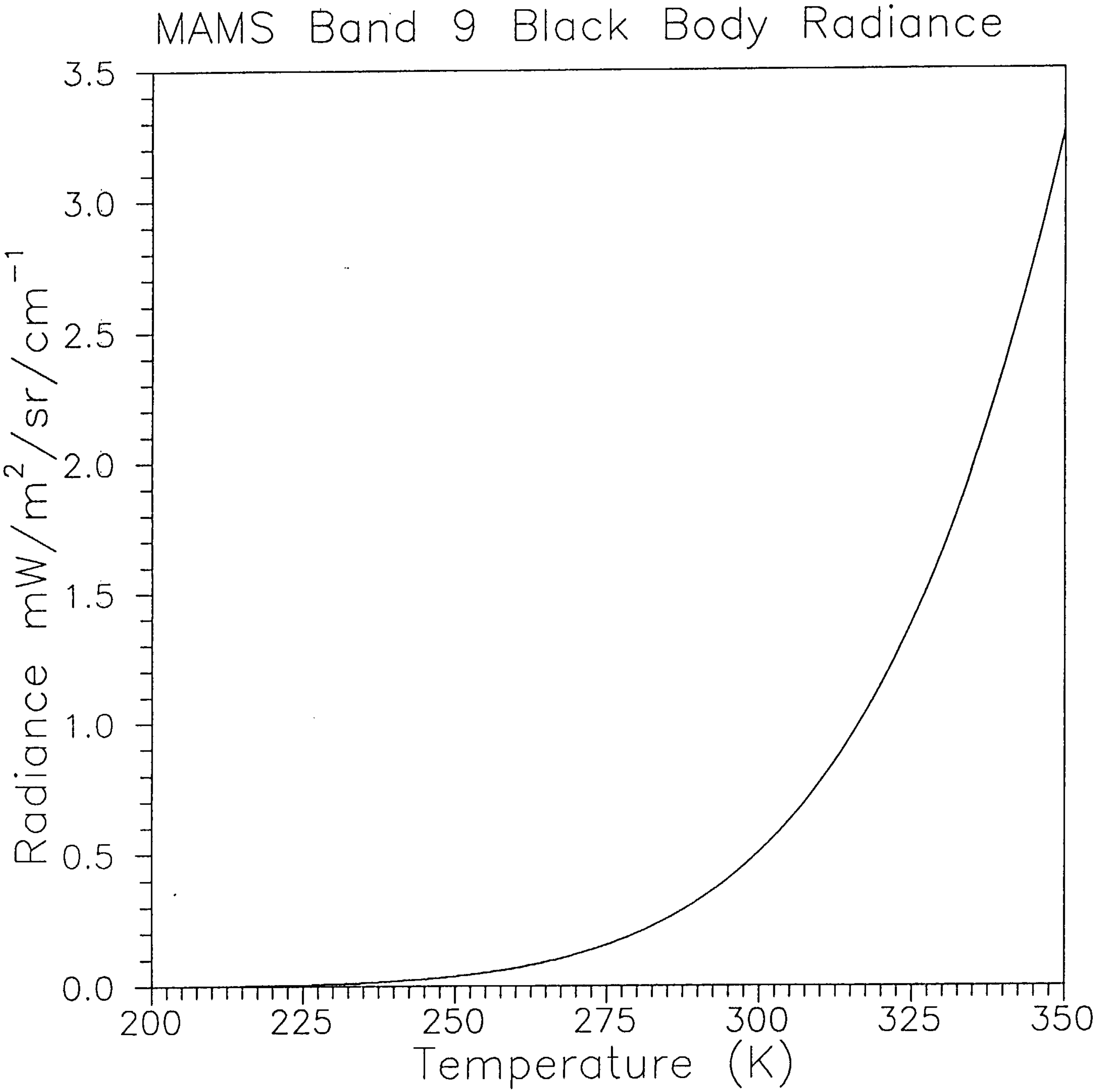
The tools for the MAS calibration are now all in place, and the remaining task is to integrate them into one controlling program. This task is underway. Testing against real calibrated MAMS radiances is on hold until the rest of the MAMS test data set is delivered.

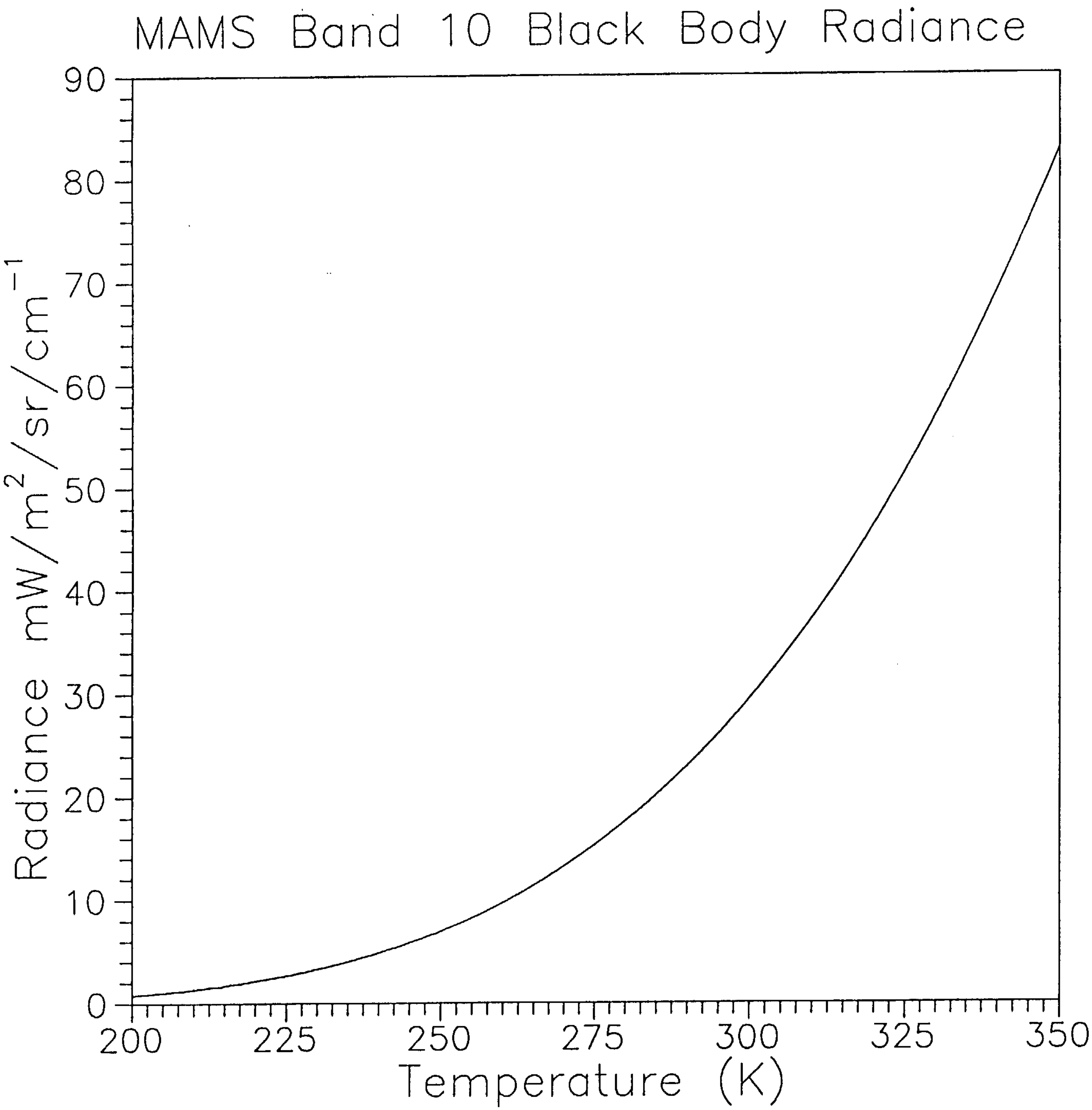
MAMS band 11 (11.2 micron) blackbody Planck radiances

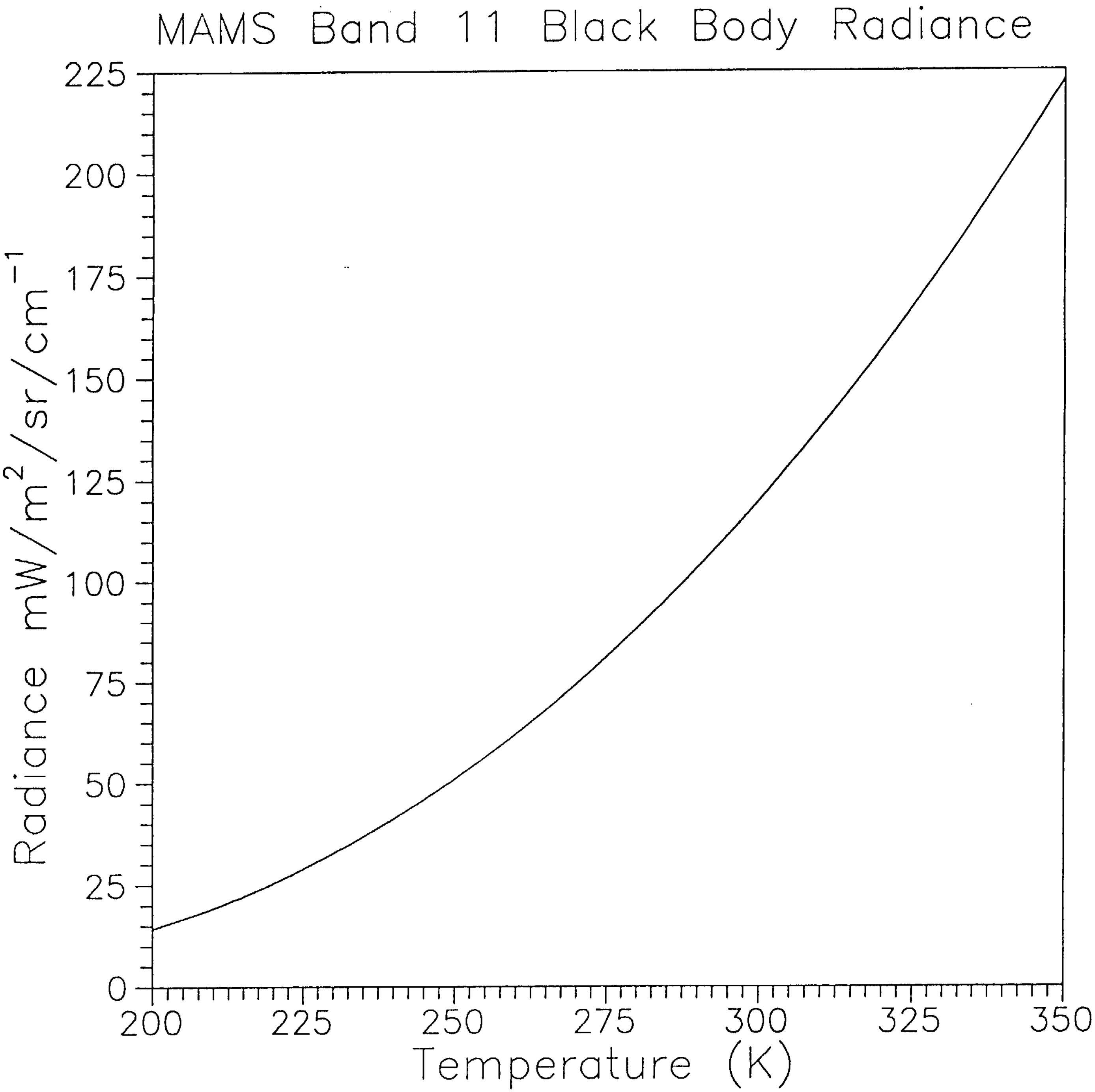
A	B	C	D
150.00000	1.74568	1.74224	.00344
155.00000	2.28904	2.28535	.00369
160.00000	2.95158	2.94772	.00386
165.00000	3.74822	3.74429	.00393
170.00000	4.69403	4.69016	.00388
175.00000	5.80412	5.80042	.00370
180.00000	7.09339	7.08999	.00340
185.00000	8.57645	8.57350	.00294
190.00000	10.26757	10.26517	.00240
195.00000	12.18041	12.17866	.00175
200.00000	14.32806	14.32707	.00099
205.00000	16.72296	16.72276	.00020
210.00000	19.37675	19.37741	-.00066
215.00000	22.30047	22.30190	-.00143
220.00000	25.50406	25.50627	-.00221
225.00000	28.99692	28.99979	-.00287
230.00000	32.78744	32.79086	-.00342
235.00000	36.88340	36.88705	-.00365
240.00000	41.29152	41.29516	-.00364
245.00000	46.01778	46.02112	-.00334
250.00000	51.06746	51.07015	-.00269
255.00000	56.44509	56.44665	-.00156
260.00000	62.15444	62.15436	.00008
265.00000	68.19847	68.19626	.00221
270.00000	74.57994	74.57478	.00516
275.00000	81.30035	81.29164	.00871
280.00000	88.36099	88.34801	.01299
285.00000	95.76256	95.74445	.01811
290.00000	103.50520	103.48120	.02408
295.00000	111.58880	111.55770	.03107
300.00000	120.01220	119.97330	.03889
305.00000	128.77460	128.72680	.04781
310.00000	137.87430	137.81650	.05779
315.00000	147.30950	147.24060	.06891
320.00000	157.07770	156.99670	.08092
325.00000	167.17710	167.08250	.09460
330.00000	177.60440	177.49510	.10931
335.00000	188.35670	188.23140	.12534
340.00000	199.43080	199.28830	.14255
345.00000	210.82370	210.66240	.16127
350.00000	222.53150	222.35010	.18132

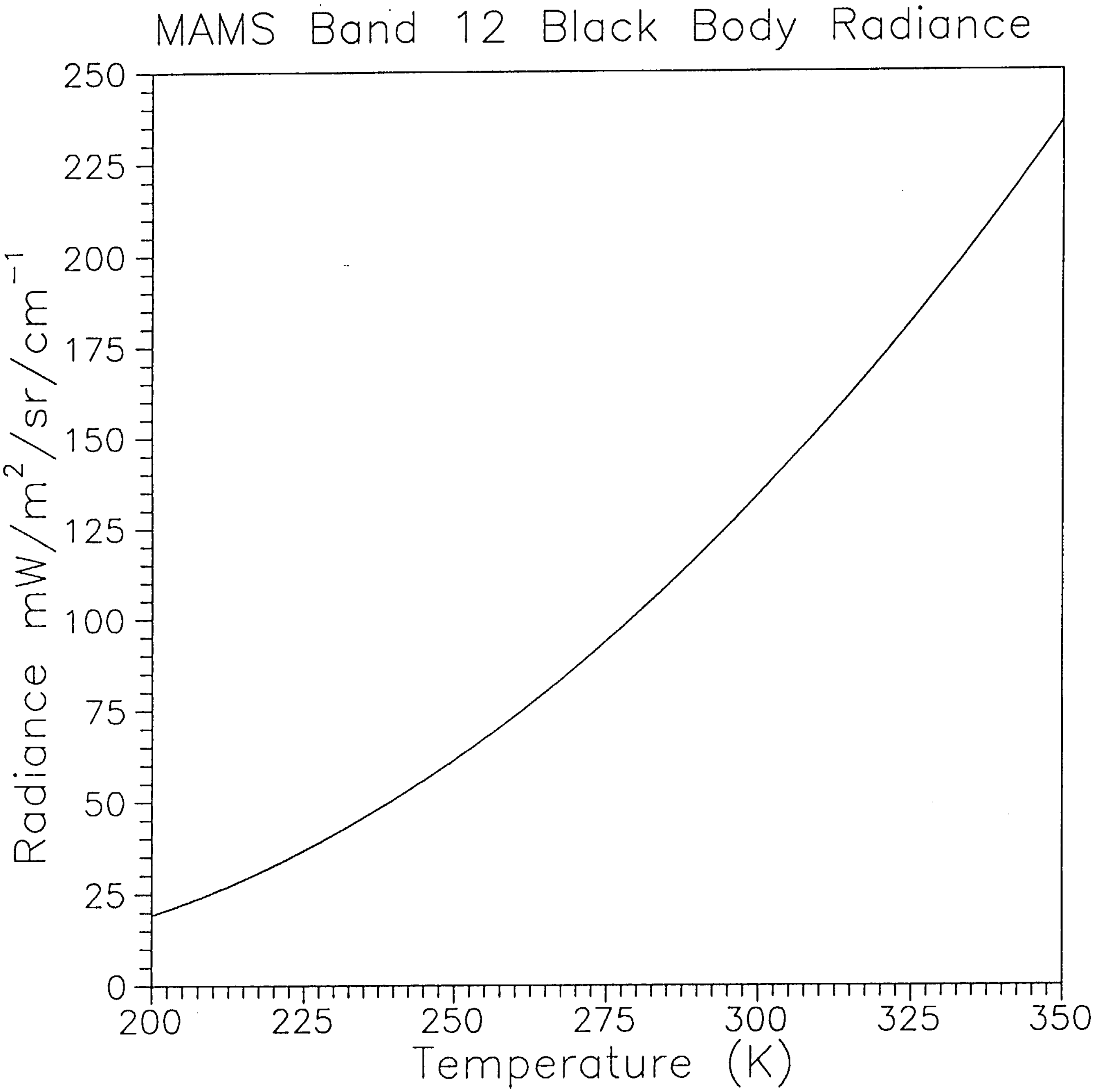
A = Temperature (K)
B = Planck radiance from MAS code $(mW/m^2/sr/cm^{-1})$
C = Planck radiance from MAMS code $(mW/m^2/sr/cm^{-1})$
D = B - C

Approximate temperature difference at 350.0 K
= (0.18132 / (222.35010 - 210.66240)) * 5.0 K = 0.07757 K


MAMS Band 9 Black Body Radiance
Radiance mW/m2/sr/cm-1
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
200
225
250
275
300
325
350
Temperature (K)


MAMS Band 10 Black Body Radiance
Radiance mW/m^2/sr/cm^-1
Temperature (K)
0
10
20
30
40
50
60
70
80
90
200
225
250
275
300
325
350


MAMS Band 11 Black Body Radiance
Radiance mW/m2/sr/cm-1
Temperature (K)
0
25
50
75
100
125
150
175
200
225
200
225
250
275
300
325
350


MAMS Band 12 Black Body Radiance
Radiance mW/m^2/sr/cm^{-1}
Temperature (K)
0
25
50
75
100
125
150
175
200
225
250
200
225
250
275
300
325
350

```
c-----------------------------------------------------------------------

      subroutine      zspl3( n, t, y, h, b, u, v, z )

c     Purpose         Compute the coefficients of a cubic spline
c                     polynomial for a given set of 'knots'.

c     Input
c     int  n          number of knots
c     real t          x coordinates of knots (STRICTLY ascending order)
c     real y          y coordinates of knots

c     Output
c     real h, b, u,   Coefficient storage arrays passed to spline
c     v, z            polynomial evaluation function SPL3.

c     Comment         Use function SPL3 to evaluate cubic spline
c                     polynomial at a given x coordinate.

c     Programmer      Liam E. Gumley, Curtin Univ.

c     Algorithm       From "Numerical Mathematics and Computing" by
c                     Ward Cheney and David Kincaid.

c     Last revised    14-SEP-1990 12:05:10

      integer*4       n, i
      real*4          t(n), y(n), h(n), b(n), u(n), v(n), z(n)

      do 2 i = 1,n-1
              h(i) = t(i+1)-t(i)
              b(i) = (y(i+1)-y(i))/h(i)
2     continue

      u(2) = 2.0 * (h(1)+h(2))
      v(2) = 6.0 * (b(2)-b(1))

      do 3 i = 3,n-1
              u(i) = 2.0 * (h(i)+h(i-1)) - h(i-1)**2/u(i-1)
              v(i) = 6.0 * (b(i)-b(i-1)) - h(i-1)*v(i-1)/u(i-1)
3     continue

      z(n) = 0.0

      do 4 i = n-1,2,-1
              z(i) = (v(i)-h(i)*z(i+1))/u(i)
4     continue

      z(1) = 0.0

      return
      end

c-----------------------------------------------------------------------

      real*4          function        spl3( n, t, y, z, x )

c     Purpose         Evaluate a cubic spline polynomial for a given
c                     x coordinate.

c     Input
c     int  n          number of knots
c     real t          x coordinate of knots (STRICTLY ascending order)
c     real y          y coordinate of knots
c     real z          coefficient storage array calculated in
c                     subroutine ZSPL3.
c     real x          x coordinate at which to find interpolated y
c                     value

c     Output
c     real spl3       interpolated y coordinate

c     Comment         Use subroutine ZSPL3 to compute the coefficients
c                     of the cubic spline polynomial.

c     Programmer      Liam E. Gumley, Curtin Univ.

c     Algorithm       From "Numerical Mathematics and Computing" by
c                     Ward Cheney and David Kincaid.

c     Last revised    14-SEP-1990 12:05:10

      integer*4       n, i
      real*4          t(n), y(n), z(n)

      do 2 i = n-1,2,-1
              diff = x-t(i)
              if(diff.ge.0.0) go to 3
2     continue

      i = 1
      diff = x-t(1)

3     h = t(i+1)-t(i)
      b = (y(i+1)-y(i))/h - h*(z(i+1) + 2.0*z(i))/6.0
      p = 0.5 * z(i) + diff*(z(i+1)-z(i))/(6.0*h)
      p = b + diff*p

      spl3 = y(i) + diff*p

      return
      end

c-----------------------------------------------------------------------
```

Date: 08/22/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

```
                                            1991
                                            JUN                  JLY           AUG           SEP           OCT           NOV
     Task             Resource/Status Date  01.....16.....30.....14.....28.....11.....25.....08.....22.....06.....20.....03.....17.....31

  MAS data user requirements survey   06/01 ================
                        LG        C   06/01 ****************
  Investigate hardware requirements   06/01 ================
                        LG        C   06/01 ****************
  Visit Wisconsin to obtain code/data 06/30               =======
                        LG        C   07/09                    **
  Specify contents of Level-1B output 06/30               =======
                        LG        C   06/30               *******
  Obtain accounts on LTP VAX and IRIS 07/12                     ========
                        LG        C   07/12                     ********
  Transfer MAMS source code to VAX    07/12                     ========
                        LG        C   07/12                     ********
  Transfer MAMS/INS data to VAX       07/12                     ========
                        LG        C   07/12                     ********
  Decode INS data file                07/12                     ========
                        LG        C   07/12                     ********
  Get straight flight tracks from INS 07/12                     ========
                        LG        C   07/12                     ********
  Find regressions of heading vs time 07/12                     ========
                        LG        C   07/12                     ********
  Investigate PCI software on IRIS    07/12                     ========
                        LG        C   07/12                     ****************
  Write code to compute regressions   07/26                            ========
                        LG        C   07/26                            ********
  Write code to unpack 8-bit imagery  07/26                            ========
                        LG        C   07/26                            ********
  Write code to get straight imagery  07/26                            ========
                        LG        C   07/26                            ********
  Display 8 bit imagery on PC, IRIS   07/26                            ========
                        LG        C   07/26                            ********
  Examine MAMS calibration code       08/09                                   ========
                        LG        C   08/09                                   ********
  Develop calibration modules, driver 08/09                                   ========
                        LG        I   08/09                                   ■■
  Test calibration against MAMS data  08/09                                   ========
                        LG        I   08/09                                   ■■
  Prepare subsampled data for IRIS    08/09                                   ========
                        LG        C   07/26                            ********
  Examine MAMS geolocation code       08/23                                          ========
                        LG
  Develop geolocation modules, driver 08/23                                          ========
                        LG
  Test geolocation against MAMS data  09/06                                                 ========
                        LG
  Integrate calibration, geolocation  09/06                                                 ========
                        LG
```

Date: 08/22/91
Each Symbol = 2 Days

MAS Level-1B Processing System
MAS01

≡ Planned
■ Actual
* Completed
M Milestone

MAS Level-1B Processing System Development at GSFC

```
                                            1991
                                            JUN                  JLY           AUG           SEP           OCT           NOV
       Task            Resource/Status Date 01.....16.....30.....14.....28.....11.....25.....08.....22.....06.....20.....03.....17.....31
Introduce users to IRIS imagery      09/06                                                  ========
                        LG
Integrate Level-1B into HDF (TEG)    09/20                                                         ========
                        LG
Process new MAMS data set            09/20                                                         ========
                        LG
Fix any bugs found                   09/20                                                         ========
                        LG
Incorporate any changes from users   09/20                                                         ========
                        LG
Integrate documentation, user guide  10/04                                                                ========
                        LG
Create HDF output, write to tape     10/04                                                                ========
                        LG
Test HDF read/write routines (TEG)   10/04                                                                ========
                        LG
Confirm MAS delivery with Ames       10/04                                                                ========
                        LG
First MAS flight for FIRE            11/18                                                                                     M
                        LG
```

Scheduler Corner Cases
(How to use 'hot links')

- missing packets from CDOS
- ancillary data incompleteness or missing
  - ephemeris
  - MCST
- algorithm differences
  - land/ocean flag
  - data required for algorithms
  - parametric variances
- A table of processing requirements for each input to this process
  - completeness quality

    determined by percentage (actual granules incomplete are contained within the data product by a bit map)
  - completeness - backwards pointer

    Need a table of backwards pointers to the input data sets required to process this output data set. and whether the input sets have passed QC.

Applicability of HDF Capabilities to MODIS Data Storage Requirements

Thomas E. Goff

Background: The three MODIS instruments: Modis Aircraft Simulator (MAS) instrument, MODIS-N, and MODIS-T spacecraft instruments, are all imaging scanners with slightly different data from each other in the spatial and precision domains as tabulated below. All three have more than 8 bits of depth (resolution) for each pixel. The data products from these instruments will also include anchor points (ground control points) with latitude, longitude, solar and instrument zenith and azimuth angles, and similar data values.
The Hierarchical Data Format (HDF) format administered by the National Center for Supercomputing Applications (NCSA) is an attempt to produce an object oriented data interchange format between most existing computer systems. The format is designed to provide all the necessary information about the data, from within the data set contents. This allows a higher level computer program to access the data sets within a file without any apriori knowledge of the format or contents of that file. The two groups of HDF data types are the Raster Image Group (RIG) and Scientific Data Group (SDG). Both of these groups support a two dimensional array data set. A further technique called (Vset) allows hierarchical and multi-variate data sets to be considered as combined objects.

Limitations: The HDF format supports 8 bit (and 3x8=24 bit) RIG and floating point two dimensional matrices. The MODIS instruments require 8-10 bits for MAS, 12 bit for MODIS-N and 13 bits for MODIS-T. As computers like to have their internal data byte aligned, a 16 bit RIG data type would be sufficient to cover these MODIS instruments. NCSA has no current plans to implement a 16 bit RIG format but acknowledges that it would be desirable.

Representing the pixel data in the SDG data type format will expand the data set by a factor of two. Integer data in the user higher level program is passed to the HDF routines which produces an IEEE floating point format in the data file. This is the only data representation that is written to the storage media (other than ASCII). In the MAS case, most of the usable data is only accurate to 8 bits (10 bits for thermal channels) which can be accurately represented in a 16 bit word after calibration is applied. This is expected to be implemented to keep data sizes as small as possible. MODIS-N and T can also be accommodated with 16 bit calibrated data.

If the anchor point data were attached to every pixel in the image, a SDG data type could be used. However, the anchor points are to be attached only to selected pixels in the scan. This would require the creation of a new data type that can map the anchor points to their corresponding scan locations. The NSCA people have an avenue to allow users to create both public and private (registered with NCSA) date types. The public types are needed to support more than one instrument or computer systems.

The Vset technique can be used as it is currently implemented to associate one anchor point data type to multiple band images. This assumes that a new RIG format would have been already implemented and added as a sub type in the HDF hierarchy.

Comments: Efforts by NSSDC for the transmission of AVHRR 10 bit data have the same problems as the MODIS data sets in respect to pixel depth.

Summary: A RIG data type needs added to HDF to handle 16 bit raster images, and an anchor point data type added for ground point association. These would most likely require programming efforts by personnel other than the NSCA people.